

**Serial No.:** 10/812,467

**Filing Date:** 3/30/2004

**Office Action Date:** 10/31/2007

**Amendment Date:** 12/20/2007

## **II. AMENDMENTS TO THE CLAIMS**

This listing of claims will replace all prior versions, and listings, of claims in this

Application:

### **Listing of Claims:**

1.-9. (Canceled)

10. (Currently Amended) Method for controlling regeneration of a NOx trap comprising:

estimating an accumulated NOx in a NOx trap located in the exhaust path of an engine;

defining a stratified engine operating region as the only region in which stratified charge combustion mode is enabled;

defining an area of low engine speed and engine load, wherein stratified charge combustion mode is highly preferred; and,

hastening regeneration of the NOx trap by reducing the size of the a stratified engine charge operating region ~~of the engine~~ when the accumulated NOx exceeds a first threshold value and initiating regeneration when engine speed and engine load do not fall within the stratified engine charge operating region of the engine is exited; wherein reducing the stratified ~~charge engine~~ operating region comprises reducing engine speed and engine load at which ~~to operate~~ the engine operates in stratified charge operating mode.

11. (Currently Amended) The method of claim 10, further comprising:

estimating ~~the a~~ temperature of the NOx trap; and,

**Serial No.:** 10/812,467

**Filing Date:** 3/30/2004

**Office Action Date:** 10/31/2007

**Amendment Date:** 12/20/2007

determining a desired air-fuel ratio for initiating regeneration of the NOx trap, the desired air-fuel ratio being determined based upon one or a combination of the estimated accumulated NOx stored within the NOx trap and the temperature of the NOx trap.

12. (Canceled)

13. (Currently Amended) The method of claim 10, further comprising:

ending regeneration and resetting the estimated accumulated NOx to ~~the~~ a level of ~~the~~ remaining stored NOx in the NOx trap when a regeneration ending event is reached.

14. (Original) The method of claim 13, further comprising:

monitoring exhaust gases flowing out of the NOx trap wherein the regeneration ending event is reached when the monitored exhaust gases flowing out of the NOx trap show a rich deviation.

15. (Currently Amended) The method of claim 13, further comprising:

monitoring ~~the~~ an elapsed regeneration event time wherein the regeneration ending event is reached when the elapsed regeneration event time exceeds a target maximum regeneration event time interval.

**Serial No.:** 10/812,467

**Filing Date:** 3/30/2004

**Office Action Date:** 10/31/2007

**Amendment Date:** 12/20/2007

16. (Original) The method of claim 13, further comprising:

monitoring driver torque demand on the engine wherein the regeneration ending event is reached when the driver torque demand drops below a threshold value.

17. (Original) The method of claim 13, wherein the regeneration ending event is triggered by a driver initiated action.

18. (Previously Presented) Article of manufacture comprising:

a storage medium having a computer program encoded therein for causing an engine controller to control a direct injection internal combustion engine selectively operative in one of a homogeneous charge combustion mode and a stratified charge combustion mode and having an exhaust gas conduit fluidly connected to a NOx trap device said program including:

code to define a first engine speed/load operating region;

code to define a second engine speed/load operating region consisting of a reduced portion of the first operating region;

code to monitor engine operation;

code to monitor temperature of the NOx trap;

code to determine a cumulative mass of NOx stored on the NOx trap device;

code to operate the engine in the stratified charge combustion mode only when the engine operation is within the first operating region and the cumulative mass of NOx stored on the NOx trap device is less than a first threshold;

**Serial No.:** 10/812,467

**Office Action Date:** 10/31/2007

**Filing Date:** 3/30/2004

**Amendment Date:** 12/20/2007

code to operate the engine in the stratified charge combustion mode when the engine operation is within the second operating region and the cumulative mass of NO<sub>x</sub> stored on the NO<sub>x</sub> trap device is greater than the first threshold;

code to control the engine-out air/fuel ratio to regenerate the NO<sub>x</sub> trap when the temperature exceeds a predetermined temperature threshold; and,

code to control the engine in the homogeneous charge combustion mode and control the engine-out air/fuel ratio to regenerate the NO<sub>x</sub> trap when the determined cumulative mass of NO<sub>x</sub> stored on the NO<sub>x</sub> trap device exceeds a second threshold, said second threshold greater than the first threshold.

19.-38. (Canceled)

39. (Previously Presented) Method for controlling regeneration of a NO<sub>x</sub> trap comprising:

estimating an accumulated NO<sub>x</sub> in a NO<sub>x</sub> trap located in the exhaust path of an engine;

estimating a temperature of the NO<sub>x</sub> trap;

determining whether the temperature of the NO<sub>x</sub> trap exceeds a threshold temperature;

determining whether the estimated NO<sub>x</sub> in the NO<sub>x</sub> trap exceeds a second threshold value greater than a first threshold value, the second predetermined threshold comprising a fraction of capacity of the NO<sub>x</sub> trap;

**Serial No.:** 10/812,467

**Filing Date:** 3/30/2004

**Office Action Date:** 10/31/2007

**Amendment Date:** 12/20/2007

determining a desired air-fuel ratio for initiating regeneration of the NOx trap, the desired air-fuel ratio being determined based upon one or a combination of the estimated NOx stored within the NOx trap and the temperature of the NOx trap; initiating regeneration of the NOx trap when the estimated NOx in the NOx trap exceeds the second threshold value or when the estimated temperature of the NOx trap exceeds the threshold temperature by forcing homogenous operation of the engine at the desired air-fuel ratio;

hastening regeneration of the NOx trap by reducing the size of a stratified charge operating region of the engine when the estimated NOx in the NOx trap exceeds the first threshold value and initiating regeneration when the stratified charge operating region of the engine is exited; and

wherein reducing the stratified charge operating region comprises reducing engine speed and engine load at which to operate the engine in stratified charge operating mode.

40. (New) Method for controlling a direct injection internal combustion engine selectively operative in one of a homogeneous charge combustion mode and a stratified charge combustion mode and having an exhaust gas conduit fluidly connected to a NOx trap generally effective to accumulate NOx emissions during lean operation of the engine and to release said accumulated NOx emissions during rich operation of the engine comprising:

defining a first engine operating region as the only region in which stratified charge combustion mode is enabled;

defining an area of low engine speed and engine load, wherein stratified charge combustion mode is highly preferred;

**Serial No.:** 10/812,467

**Filing Date:** 3/30/2004

**Office Action Date:** 10/31/2007

**Amendment Date:** 12/20/2007

defining a second operating region, comprising an area greater than the area of low engine speed and engine load and consisting of a reduced portion of the first operating region, the second operating region operative to redefine the only area in which stratified charge combustion mode is enabled;

monitoring engine operation;

determining a cumulative mass of NO<sub>x</sub> stored on the NO<sub>x</sub> trap device;

operating the engine in the stratified charge combustion mode only when the engine operation is within the first operating region and the cumulative mass of NO<sub>x</sub> stored on the NO<sub>x</sub> trap device is less than a first threshold; and

operating the engine in a stratified charge combustion mode when the engine operation is within the second operating region and the cumulative mass of the NO<sub>x</sub> stored on the NO<sub>x</sub> trap device is greater than the first threshold.

41. (New) The method of claim 40, comprising iteratively defining said second operating region, each iterative definition reducing said second operating region to a smaller area than the previous second operating region.

42. (New) The method of claim 40, wherein the first and second engine operating regions comprise engine operating regions defined in terms of an engine speed range and an engine load range.

43. (New) The method of claim 42, wherein defining the second operating region consisting of the reduced portion of the first operating region comprises reducing the engine speed range of the first operating region.

**Serial No.:** 10/812,467  
**Filing Date:** 3/30/2004

**Office Action Date:** 10/31/2007  
**Amendment Date:** 12/20/2007

44. (New) The method of claim 42, wherein defining the second operating region consisting of the reduced portion of the first operating region comprises reducing the engine speed range and the engine load range of the first operating region.

45. (New) The method of claim 40, further comprising operating the direct-injection internal combustion engine selectively operative in the homogeneous charge combustion mode when the engine operation is outside the first operating region when the cumulative mass of NO<sub>x</sub> stored on the NO<sub>x</sub> trap device is greater than the threshold.

46. (New) The method of claim 45, further comprising regenerating the NO<sub>x</sub> trap by controlling the engine-out air/fuel ratio to an air/fuel ratio rich of stoichiometry.

47. (New) The method of claim 46, comprising monitoring exhaust gas output from the NO<sub>x</sub> trap, and, ending the regenerating of the NO<sub>x</sub> trap when the monitored exhaust gas indicates a rich deviation of gases flowing out of the NO<sub>x</sub> trap.

48. (New) The method of claim 46, comprising ending the regenerating of the NO<sub>x</sub> trap upon expiration of a regeneration timer.

49. (New) The method of claim 46, comprising ending the regenerating of the NO<sub>x</sub> trap when the engine operation falls below a threshold value for the engine operating region.

50. (New) The method of claim 40, further comprising:

**Serial No.:** 10/812,467

**Filing Date:** 3/30/2004

**Office Action Date:** 10/31/2007

**Amendment Date:** 12/20/2007

monitoring temperature of the NO<sub>x</sub> trap; and,

controlling the engine-out air/fuel ratio to regenerate the NO<sub>x</sub> trap when the

temperature exceeds a predetermined temperature threshold.

51. (New) The method of claim 40, further comprising operating the engine in the homogeneous charge combustion mode and controlling the engine-out air/fuel ratio to regenerate the NO<sub>x</sub> trap when the determined cumulative mass of NO<sub>x</sub> stored on the NO<sub>x</sub> trap device exceeds a second threshold, said second threshold greater than the first threshold.